Effects of Radio Channel on Receivers

Outputs

- Analysis of bit, frame, and packet transmission reliability.
- Correlations between radio channel characteristics and receiver performance.
- Radio channel measurement requirements for receiver performance analysis.

Telecommunications play a vital role in many of the services deemed essential for modern life. For many of these services, telecommunication is provided over a radio link. Land mobile, indoor, and satellite are but a few examples of radio links commonly used. The radio link consists of a transmitter, receiver, and the channel separating the two. The radio channel is often the primary impediment to fast and reliable telecommunication. Hence, the Institute has historically focused most of its efforts towards understanding the radio channel. This project builds upon these historical strengths by studying the effects of the channel on receiver performance. Figure 1 summarizes the scope of this project.

This study requires expertise in a wide range of radio engineering disciplines. For example, this study requires detailed knowledge of receiver demodulation and signal processing methods. This is a formidable challenge considering the large number of legacy receivers and the growing numbers of receivers for emerging technologies such as personal communications services (PCS), wireless local area networks (WLAN), and global positioning system (GPS). Complexity of these receivers ranges from mere analog demodulation to digital demodulation with advanced signal processing methods including multipath equalization and error correction techniques.

This study also requires extensive knowledge of the radio channel. The radio channel is often characterized by propagation phenomena such as multipath and loss, additive noise from natural and man-made radiators, and signals from other radio links. These radio channel components affect each radio receiver uniquely. For example, PCS receivers operating in a residential neighborhood in the 1900-MHz band are primarily compromised by time-varying multipath introduced by buildings and terrain. WLAN receivers operating within buildings in the 900-, 2400-, and 5800-MHz industrial, scientific, and medical bands contend with man-made radio noise radiated by other electrical devices such as microwave ovens, in addition to multipath introduced by reflections and scattering from walls, ceilings, and objects within the room. GPS and other satellite broadcast receivers are hindered by terrestrial radio links whose signals occupy the same frequencies.

Receiver performance evaluation includes analysis of bit and frame transmission error rates. This analysis can be extended to packet transmission error rates across a network incorporating radio links. Performance evaluation metrics such as these are correlated against radio channel parameters, e.g., multipath channel root mean square delay spread, man-made noise impulsiveness, or interfering signal

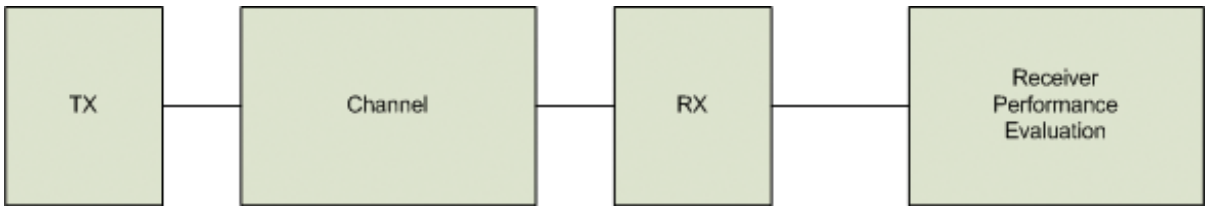

Figure 1. Scope of project includes the study of channel, receiver, and various methods of receiver performance evaluation.

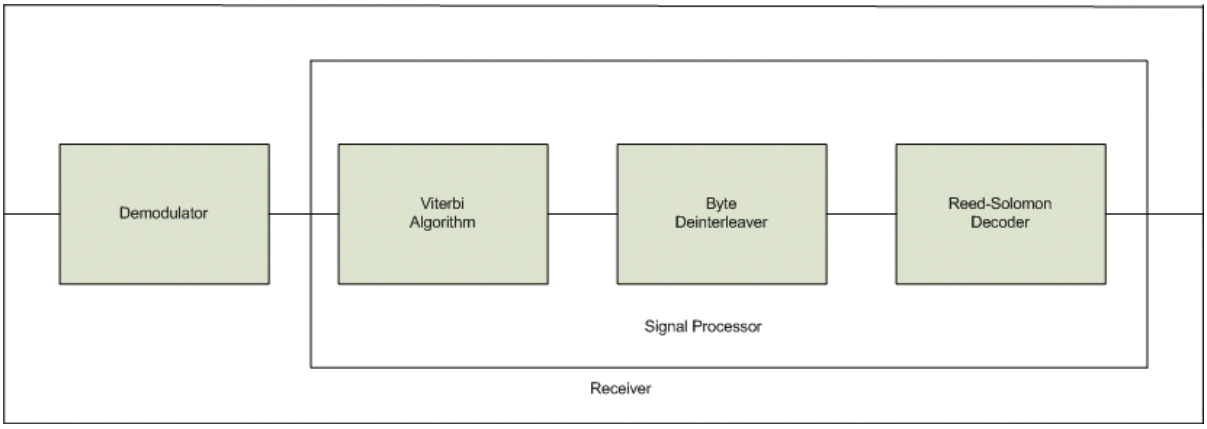

Figure 2. Block diagram of a direct broadcast satellite receiver highlighting demodulation and signal processing tasks.

level crossing rates. In addition, a considerable amount of effort is expended statistically analyzing the effect measurement uncertainties have on the performance metrics and subsequent analysis.

Success of this project is dependent on knowing the limitations of radio channel characterization measurement and analysis and how these limitations influence the study of the effects of the radio channel on the receiver. These subtleties are addressed by project personnel who have performed many of these measurements and analyses themselves and who continue to have close working relationships with those currently performing them. Project personnel are also well versed in analysis of random processes which are used to characterize radio channels and transmitted signals.

In FY 2005, project personnel focused on two primary tasks. The first task supported research within the Institute on the effects of gated Gaussian noise signals on direct broadcast satellite receiver performance. A block diagram of the direct broadcast satellite receiver with associated demodulator and signal processing components is shown in Figure 2. We supported this research by verifying measurements of the susceptibility to continuous Gaussian noise analytically and gated-Gaussian noise through simulation. We also verified gated-Gaussian noise amplitude probability distribution and the power spectral density characterization measurements. Verification of the APD measurement was critical since the effects of interferring signals on receiver performance are often correlated to the peak to average power ratio provided by the APD.

The second task concerned the calculation of the uncertainties of radio channel characterization measurements. These uncertainties are rarely reported in professional journal articles. Our goal is to describe how the uncertainties are computed from a finite sample set and show how they can be used in multipath, man-made noise, and signal characterization measurement analysis. In the future, these uncertainties will be translated to receiver performance parameters.

Recent Publications

M. Cotton, R. Achatz, J. Wepman, and P. Runkle, "Appendix B: Verification of susceptibility results" in "Interference potential of ultrawideband signals - Part 2: Measurement of gated-noise interference to C-band satellite digital television receivers," NTIA Report TR-05-429, Aug. 2005.

R. Dalke, "Statistical considerations for noise and interfering characterization measurements," NTIA Report, in progress.

R. Dalke and G. Hufford,"Analysis of the Markov character of a general Rayleigh fading channel," NTIA Technical Memorandum TM-05-423, Apr. 2005.

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